Scottish & Southern Electricity Networks

TRANSMISSION

Carnaig 400 kV Substation

Environmental Impact Assessment

Volume 4

Technical Appendix 6.1

Carbon Calculator Data

August 2024

Carbon Calculator v1.8.1
Loch Buidhe Substation Location: 57.945929 -4.281449
SSE

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	1	1	1	No turbines in development - modifying carbon calculator for a substation development. Represents platform foundation and other areas of hardstanding (except tracks). 1 is the minimum number accepted by the calculator.
Duration of consent (years)	100	100	100	Permission to build and operate substation is being applied for in perpetuity. 100 years is the maximum duration that the calculator accepts.
Performance				
Power rating of 1 turbine (MW)	0.001	0.0001	0.002	N/A - no turbines; have kept this as low as possible to minimise savings calculated by calculator.
Capacity factor	0.001	0.0001	0.002	N/A- no turbines; have kept this as low as possible to minimise savings calculated by tool.
Backup				
Fraction of output to backup (%)	0	0	0	N/A- no turbines and therefore no backup proposed.
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO2 emission from turbine life (tCO2 MW^{-1}) (eg. manufacture, construction, decommissioning)	0.001	0.0001	0.002	N/A- manufacturing C of materials been scoped out due to difficulties in identifying carbon emissions from the different materials used in substation construction. Value for calculator kept to a minimum to minimise losses associated with this.
Characteristics of peatland before windfarm development				
Type of peatland	Acid bog	Acid bog	Acid bog	Ecological Surveys have identified the peatland type.
Average annual air temperature at site (°C)	7.165	7.164	7.166	MetOffice Climate Averages - Loch Gladcarnoch (closest station; 16 miles away) - https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gfk82sdb6
Average depth of peat at site (m)	0.9	0.8	1	Determined by peat probing surveys.
C Content of dry peat (% by weight)	53.23	19.57	64.28	Standard figures from the Soil Survey for Scotland
Average extent of drainage around drainage features at site (m)	10	5	50	Standard figures as per Carbon Calculator guidance https://informatics.sepa.org.uk/CarbonCalculator/assets/Carbon_calculator_User_Guidance.pdf
Average water table depth at site (m)	1	0.9	1	Measured for Drainage Impact Assessment; Actual measure is 1.327 m but calculator does not allow above 1m.
Dry soil bulk density (g cm^{-3})	0.132	0.072	0.293	As per guidance; industry standard.
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	5	2	10	Technical Estimation - Not expected to deviate from standard regeneration timescales.
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31	SNH Guidance provided by Carbon Calculator Notes.
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	66.08	66.07	66.09	Area of forestry needing to be felled for the Proposed Development; provided by forestry consultant and in line with forestry EIA Chapter.
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	2.5	4.7	Scottish Government and NatureScot Guidance, provided in Carbon Calculator Notes.

Input data	Expected value	Minimum value	Maximum value	Source of data
Counterfactual emission factors				
Coal-fired plant emission factor (t CO_2 MWh^{-1})	0.945	0.945	0.945	
Grid-mix emission factor (t CO_2 MWh^{-1})	0.207	0.207	0.207	
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.424	0.424	0.424	
Borrow pits				
Number of borrow pits	0	0	0	No borrow pits proposed with the Proposed Development at this time.
Average length of pits (m)	0	0	0	
Average width of pits (m)	0	0	0	
Average depth of peat removed from pit (m)	0	0	0	
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	530	530	530	Measured from Layout Figure 2.1 in the EIA Report
Average width of turbine foundations (m)	324	324	324	Measured from Layout Figure 2.1 in the EIA Report
Average depth of peat removed from turbine foundations(m)	1.316	1.316	1.316	Determined from peat probing data.
Average length of hard-standing (m)	160	160	160	Measured from Layout Figure 2.1 in the EIA Report
Average width of hard-standing (m)	75	75	75	Measured from Layout Figure 2.1 in the EIA Report
Average depth of peat removed from hard-standing (m)	1.8	1.8	1.8	Determined from peat probing data
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	2450	2450	2450	Provided by the Applicant
Access tracks				
Total length of access track (m)	700	699	701	Measured from Figure 2.1 in the EIA Report.
Existing track length (m)	0	0	0	No existing tracks onsite.
<u>Length of access track that is floating road (m)</u>	0	0	0	No floating roads proposed for the Proposed Development.
Floating road width (m)	0	0	0	
Floating road depth (m)	0	0	0	
Length of floating road that is drained (m)	0	0	0	
Average depth of drains associated with floating roads (m)	0	0	0	
<u>Length of access track that is excavated road (m)</u>	700	699	701	Measured from Figure 2.1 in the EIA Report
Excavated road width (m)	5	5	5.1	Measured from Figure 2.1 in the EIA Report
Average depth of peat excavated for road (m)	1.207	1.206	1.208	Provided from peat probing data; average across both permanent and temporary roads.

Input data	Expected value	Minimum value	Maximum value	Source of data
Length of access track that is rock filled road (m)	0	0	0	No rock filled roads proposed with the Proposed Development.
Rock filled road width (m)	0	0	0	
Rock filled road depth (m)	0	0	0	
Length of rock filled road that is drained (m)	0	0	0	
Average depth of drains associated with rock filled roads (m)	0	0	0	
Cable trenches				
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)	3768	3768	3768	Measured from planning drawing CAAIA-LT470-JMS-CRTAC-XX-LAY-EU-0001
Average depth of peat cut for cable trenches (m)	0.9	0.8	1	Not calculated - assumed same average depth as there is across the Site.
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	3815.73	3815	3816	Measured from peat probing data and includes SUDS features and drainage channels.
Area of additional peat excavated (m^2)	3282.348	3282	3283	Measured from site layout plans and peat probing information.
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	negligible	negligible	negligible	Fixed
Improvement of C sequestration at site by blocking drains, restoration of habitat etc				
Improvement of degraded bog				
Area of degraded bog to be improved (ha)	190	189	191	Restoration proposed in 'Peatland Restoration Area' on Figure 2.1 in the EIA Report.
Water table depth in degraded bog before improvement (m)	1	0.9	1.1	Water table depth not measured in peatland restoration area; used average for Site.
Water table depth in degraded bog after improvement (m)	0.5	0.4	0.6	Estimate provided; water table depth likely to decrease with peatland restoration.
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	20	15	30	BNG Tool - 20 years used for conifer forest conversion. For restoration of degraded wet modified bog and blanket bog, 15 years minimum has been assumed, 30 years is usually taken to be the timeframe for bog restoration from forestry, so that would be considered a precautionary value.
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	20	15	30	BNG Tool - 20 years used for conifer forest conversion. For restoration of degraded wet modified bog and blanket bog, 15 years minimum has been assumed, 30 years is usually taken to be the timeframe for bog restoration from forestry, so that would be considered a precautionary value.

Input data	Expected value	Minimum value	Maximum value	Source of data
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	0	0	0	Compensatory Planting has been committed to but is not included in the EIA.
Water table depth in felled area before improvement (m)	0	0	0	Compensatory Planting has been committed to but is not included in the EIA.
Water table depth in felled area after improvement (m)	0	0	0	Compensatory Planting has been committed to but is not included in the EIA.
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	2	2	2	Compensatory Planting has been committed to but is not included in the EIA. Minimum value possible used.
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	2	2	2	Compensatory Planting has been committed to but is not included in the EIA. Minimum value possible used.
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	0	0	0	No borrow pit proposed with the Proposed Development.
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	0	0	0	No borrow pit proposed with the Proposed Development.
Depth of water table in borrow pit after restoration with respect to the restored surface (m)	0	0	0	No borrow pit proposed with the Proposed Development.
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	1	1	2	No borrow pit proposed with the Proposed Development.
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)	2	2	3	No borrow pit proposed with the Proposed Development.
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0	0	0	No decommissioning (and therefore restoration of infrastructure) proposed with the Proposed Development.

Input data	Expected value	Minimum value	Maximum value	Source of data
Water table depth around foundations and hardstanding after restoration (m)	0	0	0	No decommissioning (and therefore restoration of infrastructure) proposed with the Proposed Development.
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0.1	0.1	0.2	No decommissioning (and therefore restoration of infrastructure) proposed with the Proposed Development.
Restoration of site after decomissioning				
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you attempt to block any gullies that have formed due to the windfarm?	n/a	n/a	n/a	Decommissioning will not take place so no restoration to occur after it.
Will you attempt to block all artificial ditches and facilitate rewetting?	n/a	n/a	n/a	Decommissioning will not take place so no restoration to occur after it.
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	n/a	n/a	n/a	Decommissioning will not take place so no restoration to occur after it.
Will you manage areas to favour reintroduction of species	n/a	n/a	n/a	Decommissioning will not take place so no restoration to occur after it.
Methodology				
Choice of methodology for calculating emission factors	Site specific (required for planning applications)			

Forestry input data

N/A

Construction input data

N/A

Payback Time

1. Windfarm CO_2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO_2 / yr)	0	0	0
...grid-mix of electricity generation (t CO_2 / yr)	0	0	0
...fossil fuel-mix of electricity generation (t CO_2 / yr)	0	0	0
Energy output from windfarm over lifetime (MWh)	0	0	0

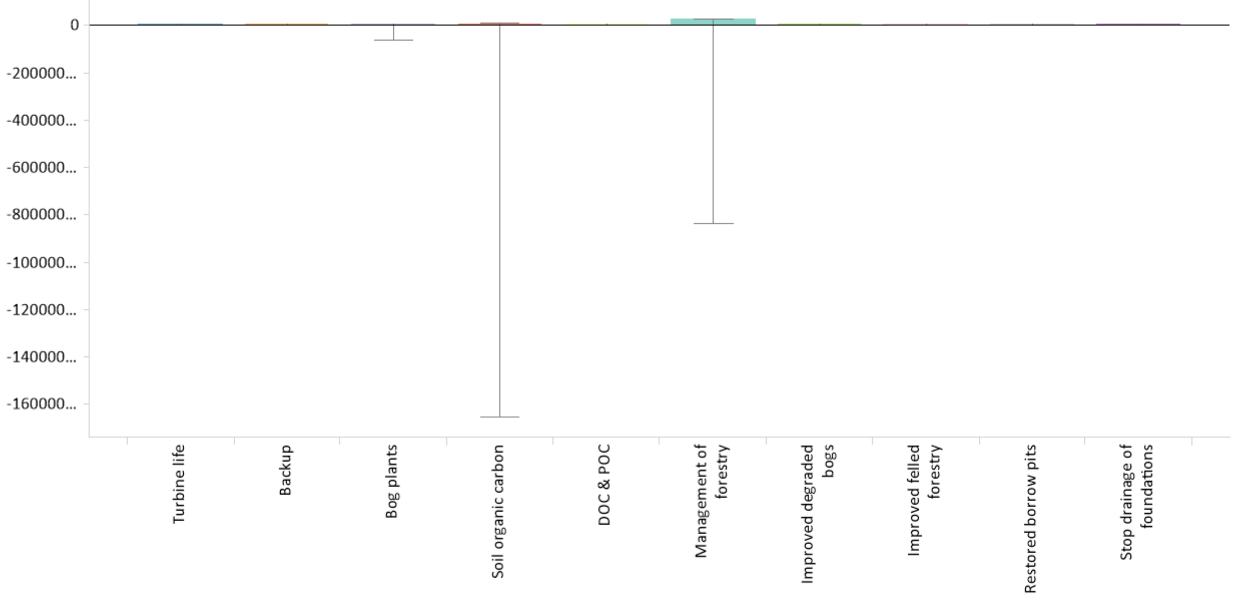
Total CO_2 losses due to wind farm (tCO_2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	0	0	0
3. Losses due to backup	0	0	0
4. Lossess due to reduced carbon fixing potential	2,930	1,110	9,683
5. Losses from soil organic matter	20,434	-30,917	129,658
6. Losses due to DOC & POC leaching	0	0	0
7. Losses due to felling forestry	87,226	60,565	113,896
Total losses of carbon dioxide	110,590	30,757	253,237

8. Total CO_2 gains due to improvement of site (t CO_2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	0	0	-44,566
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	0	0	-44,566

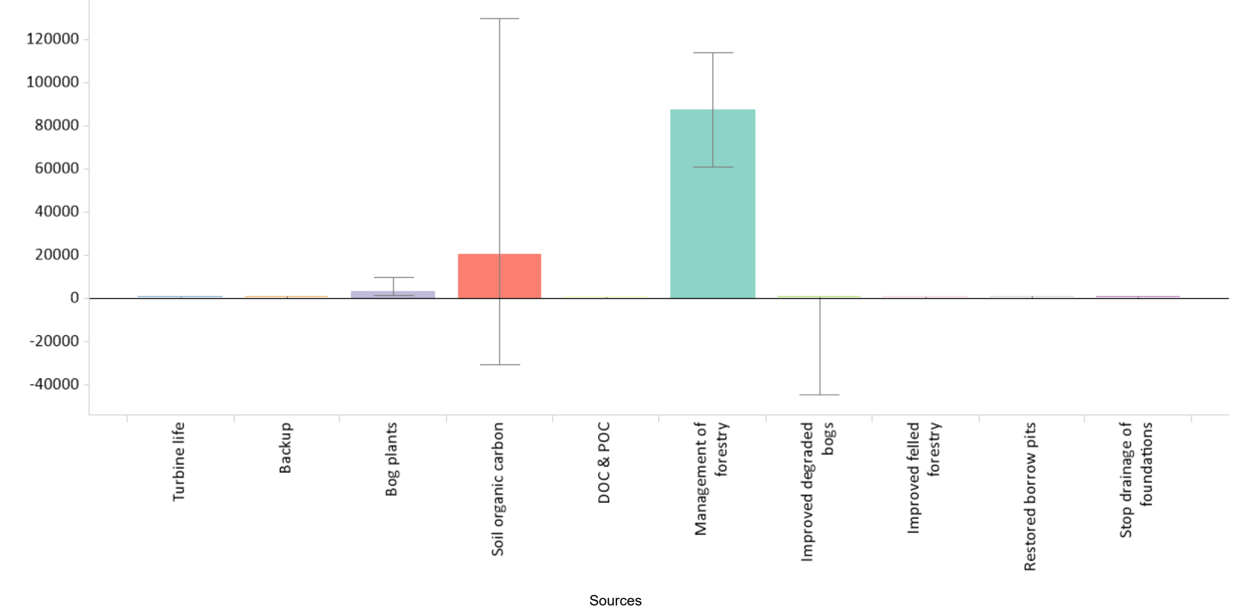
RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO_2 eq.)	110,590	-13,809	253,237
Carbon Payback Time			
...coal-fired electricity generation (years)	1,335,924,4...	-41,702,011.3	305,908,331...
...grid-mix of electricity generation (years)	6,098,785,4...	-190,378,74...	1,396,538,0...
...fossil fuel-mix of electricity generation (years)	2,977,473,1...	-92,944,341.3	681,800,408...
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	No gains!	-0.69	No gains!
Ratio of CO_2 eq. emissions to power generation (g/kWh) (for info. only)	1262448594...	-394084006....	2890833733...

Payback Time - Charts

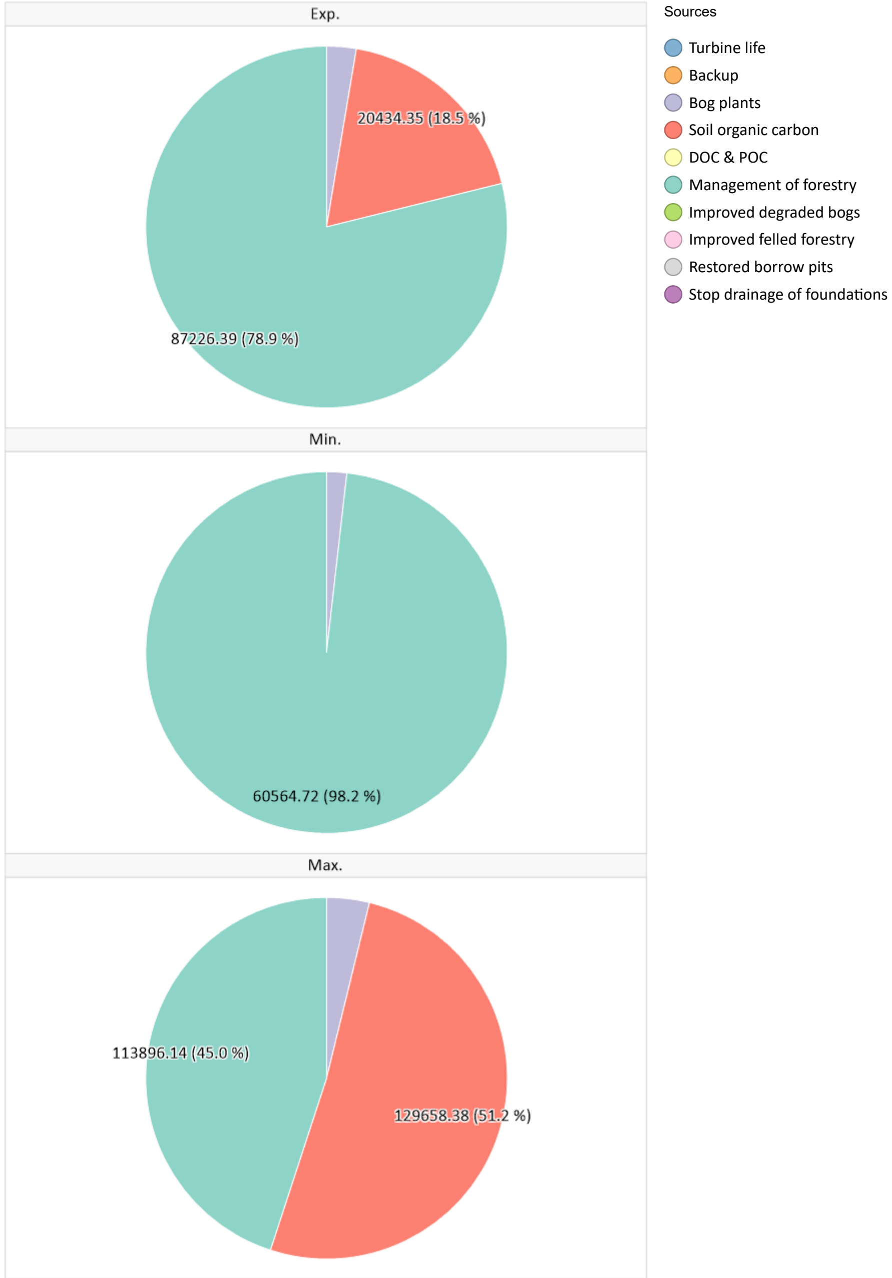
Carbon payback time (months) using fossil-fuel mix as conterfactual



Greenhouse gas emissions (t CO2 eq.)



Proportions of greenhouse gas emissions from different sources



1. CO_2 emission saving

Emissions due to turbine life
The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Capacity factor calculated from forestry data

Area name	Value type	Capacity factor (%)	Wind speed ratio	Average site windspeed (m/s)	Annual theoretical energy output (MW / turbine yr)

Capacity factor - Direct input

	Exp.	Min.	Max.
Capacity factor (%)	0.0	0.0	0.0

	Exp.	Min.	Max.
Annual energy output from windfarm (MW/yr)			
RESULTS			
Emissions saving over coal-fired electricity generatio...	0	0	0
Emissions saving over grid-mix of electricity generati...	0	0	0
Emissions saving over fossil fuel - mix of electricity g...	0	0	0

2. CO2 loss turbine life

Emissions due to turbine life

The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Calculation of emissions with relation to installed capacity

	Exp.	Min.	Max.
Emissions due to turbine frome energy output (t CO2)	0	0	1
Emissions due to cement used in construction (t CO2)	774	774	774

Direct input of emissions due to turbine life

	Exp.	Min.	Max.
Emissions due to turbine life (tCO2/windfarm)	0	0	0

RESULTS

	Exp.	Min.	Max.
Losses due to turbine life (manufacture, construction, etc.) (t CO2)	0	0	0
Additional CO2 payback time of windfarm due to turbine life			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	1	1	1
...fossil fuel - mix of electricity generation (months)	0	0	0

3. CO2 loss backup

Emissions due to backup power generation
CO2 loss due to back up is calculated from the extra capacity required for backup of the windfarm given in the input data.

Wind generated electricity is inherently variable, providing unique challenges to the electricity generating industry for provision of a supply to meet consumer demand (Netz, 2004). Backup power is required to accompany wind generation to stabilise the supply to the consumer. This backup power will usually be obtained from a fossil fuel source. At a high level of wind power penetration in the overall generating mix, and with current grid management techniques, the capacity for fossil fuel backup may become strained because it is being used to balance the fluctuating consumer demand with a variable and highly unpredictable output from wind turbines (White, 2007). The Carbon Trust (Carbon Trust/DTI, 2004) concluded that increasing levels of intermittent generation do not present major technical issues at the percentages of renewables expected by 2010 and 2020, but the UK renewables target at the time of that report was only 20%. When national reliance on wind power is low (less than ~20%), the additional fossil fuel generated power requirement can be considered to be insignificant and may be obtained from within the spare generating capacity of other power sectors (Dale et al, 2004). However, as the national supply from wind power increases above 20%, without improvements in grid management techniques, emissions due to backup power generation may become more significant. The extra capacity needed for backup power generation is currently estimated to be 5% of the rated capacity of the wind plant if wind power contributes more than 20% to the national grid (Dale et al 2004). Moving towards the SG target of 50% electricity generation from renewable sources, more short-term capacity may be required in terms of pumped-storage hydro-generated power, or a better mix of offshore and onshore wind generating capacity. Grid management techniques are anticipated to reduce this extra capacity, with improved demand side management, smart meters, grid reinforcement and other developments. However, given current grid management techniques, it is suggested that 5% extra capacity should be assumed for backup power generation if wind power contributes more than 20% to the national grid. At lower contributions, the extra capacity required for backup should be assumed to be zero. These assumptions should be revisited as technology improves.

Assumption: Backup assumed to be by fossil-fuel-mix of electricity generation. Note that hydroelectricity may also be used for backup, so this assumption may make the value for backup generation too high. These assumptions should be revisited as technology develops.

	Exp.	Min.	Max.
Reserve energy (MWh/yr)	0	0	0
Annual emissions due to backup from fossil fuel-mix of electricity generation (tCO2/yr)	0	0	0
RESULTS			
Total emissions due to backup from fossil fuel-mix of electricity generation (tCO2)	0	0	0

4. Loss CO2 fixing pot.

Emissions due to loss of bog plants

Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation.

	Exp.	Min.	Max.
Area where carbon accumulation by bog plants is lost (ha)	30.44	24.73	77.44
Total loss of carbon accumulation up to time of restoration (tCO2 eq./ha)	96	45	125
RESULTS			
Total loss of carbon fixation by plants at the site (t CO2)	2930	1110	9683
Additional CO2 payback time of windfarm due to loss of CO2 fixing potential			
...coal-fired electricity generation (months)	424694618	16085705296	350892105
...grid-mix of electricity generation (months)	1938823255	73434741571	1601898739
...fossil fuel - mix of electricity generation (months)	946548146	35851395059	782059054

5. Loss of soil CO2 (a, b)

Emissions due to loss of soil organic carbon
Loss of C stored in peatland is estimated from % site lost by peat removal (table 5a), CO2 loss from removed peat (table 5b), % site affected by drainage (table 5c), and the CO2 loss from drained peat (table 5d).

Volume of Peat Removed
% site lost by peat removal is estimated from peat removed in borrow pits, turbine foundations, hard-standing and access tracks. If peat is removed for any other reason, this must be added in as additional peat excavated in the core input data entry.

5. Loss of soil C02

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2 equiv.)	20434.35	-30917.3	129658....
CO2 loss from drained peat (t CO2 equiv.)	0	0	0
RESULTS			
Total CO2 loss from peat (removed + drained) (t CO2 equiv.)	20434.35	-30917.3	129658....
Additional CO2 payback time of windfarm due to loss of soil C...			
...coal-fired electricity generation (months)	296214...	-448174...	469878...
...grid-mix of electricity generation (months)	135228...	-204601...	214509...
...fossil fuel - mix of electricity generation (months)	660194...	-998878...	104725...

5a. Volume of peat removed

	Exp.	Min.	Max.
Peat removed from borrow pits			
Area of land lost in borrow pits (m2)	0	0	0
Volume of peat removed from borrow pits (m3)	0	0	0
Peat removed from turbine foundations			
Area of land lost in foundation (m2)	171720	171720	171720
Volume of peat removed from foundation area (m3)	225983.52	225983.52	225983.52
Peat removed from hard-standing			
Area of land lost in hard-standing (m2)	12000	12000	12000
Volume of peat removed from hard-standing area (m3)	21600	21600	21600
Peat removed from access tracks			
Area of land lost in floating roads (m2)	0	0	0
Volume of peat removed from floating roads (m3)	0	0	0
Area of land lost in excavated roads (m2)	3500	3495	3575.1
Volume of peat removed from excavated roads (m3)	4224.5	4214.97	4318.72
Area of land lost in rock-filled roads (m2)	0	0	0
Volume of peat removed from rock-filled roads (m3)	0	0	0
Total area of land lost in access tracks (m2)	3500	3495	3575.1
Total volume of peat removed due to access tracks (m3)	4224.5	4214.97	4318.72
RESULTS			
Total area of land lost due to windfarm construction (m2)	190502.35	190497	190578.1
Total volume of peat removed due to windfarm construction (m3)	255623.75	255613.49	255718.24

CO_2 loss from removed peats
If peat is treated in such a way that it is permanently restored, so that less than 100% of the C is lost to the atmosphere, a lower percentage can be entered in cell C10.

5b. CO2 loss from removed peat

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2)	65857.76	13206.34	176595....
CO2 loss from undrained peat left in situ (t CO2)	45423.42	44123.64	46937.50
RESULTS			
CO2 loss atributable to peat removal only (t CO2)	20434.35	-30917....	129658....

5. Loss of soil CO2 (c,d,e)

5. Loss of soil CO_2 (c, d, e) • NQIF-SX8K-ULZQ v4

Volume of peat drained
Extent of site affected by drainage is calculated assuming an average extent of drainage around each drainage feature as given in the input data.

CO_2 loss due to drainage
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been derived directly from experimental data for acid bogs and fens (see Nayak et al, 2008 - Final report).

5c. Volume of peat drained

	Exp.	Min.	Max.
Total area affected by drainage around borrow pits (m2)	0	0	0
Total volume affected by drainage around borrow pits (m3)	0	0	0
Peat affected by drainage around turbine foundation and hardstanding			
Total area affected by drainage of foundation and hardstanding area (m2)	22180	10990	118900
Total volume affected by drainage of foundation and hardstanding area (m3)	19962	9891	107010
Peat affected by drainage of access tracks			
Total area affected by drainage of access track(m2)	14000	6990	70100
Total volume affected by drainage of access track(m3)	8449	4214.97	42340.4
Peat affected by drainage of cable trenches			
Total area affected by drainage of cable trenches(m2)	75360	37680	376800
Total volume affected by drainage of cable trneches(m3)	33912	15072	188400
Drainage around additional peat excavated			
Total area affected by drainage (m2)	2345.1	1093.96	18009.69
Total volume affected by drainage (m3)	2726.18	1271.23	20939.97
RESULTS			
Total area affected by drainage due to windfarm (m2)	113885.1	56753.96	583809.69
Total volume affected by drainage due to windfarm (m3)	65049.18	30449.2	358690.37

5d. CO2 loss from drained peat

	Exp.	Min.	Max.
Calculations of C Loss from Drained Land if Site is NOT Restored after Decomissioning			
Total GHG emissions from Drained Land (t CO2 equiv.)	16758.98	1573.17	247707.18
Total GHG emissions from Undrained Land (t CO2 equiv.)	16758.98	1573.17	247707.18
Calculations of C Loss from Drained Land if Site IS Restored after Decomissioning			
Losses if Land is Drained			
CH4 emissions from drained land (t CO2 equiv.)	-417.41	-202.13	-2239.92
CO2 emissions from drained land (t CO2)	27572.19	13347.7	146026.47
Total GHG emissions from Drained Land (t CO2 equiv.)	27154.78	13145.57	143786.55
Losses if Land is Undrained			
CH4 emissions from undrained land (t CO2 equiv.)	-417.41	-202.13	-2239.92
CO2 emissions from undrained land (t CO2)	27572.19	13347.7	146026.47
Total GHG emissions from Undrained Land (t CO2 equiv.)	27154.78	13145.57	143786.55
RESULTS			
Total GHG emissions due to drainage (t CO2 equiv.)	0	0	0

Emission rates from soils
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

5e. Emission rates from soils

	Exp.	Min.	Max.
Annual rate of methane emission (t CH4-C/ha year)	0.04	0.04	0.04
Annual rate of carbon dioxide emission (t CO2/ha year)	35.2	35.2	35.2
Calculations following ECOSSE based methodology			
Total area affected by drainage due to wind farm construction (ha)	11.39	5.68	58.38
Average water table depth of drained land (m)	1	1	0.9
Selected emission characteristics following site specific methodology			
Rate of carbon dioxide emission in drained soil (t CO2/ha year)	23.06	23.06	22.74
Rate of carbon dioxide emission in undrained soil (t CO2/ha year)	23.06	23.06	22.74
Rate of methane emission in drained soil (t CH4-C/ha year)	-0.01	-0.01	-0.01
Rate of methane emission in undrained soil (t CH4-C/ha year)	-0.01	-0.01	-0.01
RESULTS			
Selected rate of carbon dioxide emission in drained soil (t CO2/ha year)	23.06	23.06	22.74
Selected rate of carbon dioxide emission in undrained soil (t CO2/ha year)	23.06	23.06	22.74
Selected rate of methane emission in drained soil (t CH4-C/ha year)	-0.01	-0.01	-0.01
Selected rate of methane emission in undrained soil (t CH4-C/ha year)	-0.01	-0.01	-0.01

6. CO2 loss DOC & POC

Emissions due to loss of DOC and POC
Note, CO2 losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO2 loss that is due to DOC or POC leaching.

No POC losses for bare soil included yet. If extensive areas of bare soil is present at site need modified calculation (Birnie et al, 1991)

	Exp.	Min.	Max.
Gross CO2 loss from restored drained land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from restored drained land (t CO2 equiv.)	0.00	0.00	0.00
Gross CO2 loss from improved land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from improved land (t CO2 equiv.)	0.00	0.00	0.00
Total gaseous loss of C (t C)	0.00	0.00	0.00
Total C loss as DOC (t C)	0.00	0.00	0.00
Total C loss as POC (t C)	0.00	0.00	0.00
RESULTS			
Total CO2 loss due to DOC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to POC leaching (t CO2)	0.00	0.00	0.00
Total CO2 loss due to DOC & POC leaching (t CO2)	0.00	0.00	0.00
Additional CO2 payback time of windfarm due to DOC & POC			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	0	0	0
...fossil fuel - mix of electricity generation (months)	0	0	0

7. Forestry CO2 loss

CO_2 loss from forests - calculation using detailed management information
Forest carbon calculator (Perks et al, 2009)

Total potential carbon squestration loss due to felling of forestry for the wind farm (t CO2)	
Total emissions due to cleared land (t CO2)	
Emissions due to harvesting operations (t CO2)	
Fossil fuel equivalent saving from use of felled forestry as biofuel (t CO2)	
Fossil fuel equivalent saving from use of replanted forestry as biofuel (t CO2)	
RESULTS	
Total carbon loss associated with forest management(t CO2)	

Emissions due to forest felling - calculation using simple management data
Emissions due to forestry felling are calculated from the reduced carbon sequestered per crop rotation. If the forestry was due to be removed before the planned development, this C loss is not attributable to the wind farm and so the area of forestry to be felled should be entered as zero.

	Exp.	Min.	Max.
Area of forestry plantation to be felled (ha)	66.08	66.07	66.09
Carbon sequestered (t C ha-1 yr-1)	3.6	2.5	4.7
Lifetime of windfarm (years)	100	100	100
Carbon sequestered over the lifetime of the windfarm (t C ha-1)	360	250	470
RESULTS			
Total carbon loss due to felling of forestry (t CO2)	87226.39	60564.72	113896.14
Additional CO2 payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	12644254977...	87794038196...	4127568870.41
...grid-mix of electricity generation (months)	57723772721...	40079887002...	18843249190...
...fossil fuel - mix of electricity generation (months)	28181181493...	19567303324...	9199416468.24

8. CO2 gain - site improvement

Gains due to site improvement

Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

Degraded Bog

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	190	189	191
Depth of peat above water table before improvement (m)	0.9	0.8	1
Depth of peat above water table after improvement (m)	0.5	0.6	0.4
2. Losses with improvement			
Improved period (years)	0	15	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	-0.01	-0.011	-0.008
CH4 emissions from improved land (t CO2 equiv.)	0	0	-333.758
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	17.915	20.004	14.872
CO2 emissions from improved land (t CO2 equiv.)	0	0	21828.902
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	21495.144
3. Losses without improvement			
Improved period (years)	0	15	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	-0.011	-0.011	-0.011
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	22.739	22.214	23.058
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	66060.94
Total GHG emissions from unimproved land (t CO2 eqiv.)	0	0	66060.94
RESULTS			
4. Reduction in GHG emissions due to improvement of site			
Reduction in GHG emissions due to improvement (t CO2 equiv.)	0	0	44565.796

Felled Forestry

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.489	0.489	0.489
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	-0.219	-0.219	-0.219
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	0	0	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.489	0.489	0.489
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	-0.219	-0.219	-0.219
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0
Total GHG emissions from unimproved land (t CO2 eqiv.)	0	0	0
RESULTS			
4. Reduction in GHG emissions due to improvement of site			
Reduction in GHG emissions due to improvement (t CO2 equiv.)	0	0	0

Borrow Pits

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	1	2	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.489	0.489	0.489
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	-0.219	-0.219	-0.219
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	1	2	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.489	0.489	0.489
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	-0.219	-0.219	-0.219
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0
Total GHG emissions from unimproved land (t CO2 eqiv.)	0	0	0
RESULTS			
4. Reduction in GHG emissions due to improvement of site			
Reduction in GHG emissions due to improvement (t CO2 equiv.)	0	0	0

Foundations & Hardstanding

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	99.9	99.9	99.8
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.489	0.489	0.489
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	-0.219	-0.219	-0.219
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	99.9	99.9	99.8
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.489	0.489	0.489
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	-0.219	-0.219	-0.219
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0
Total GHG emissions from unimproved land (t CO2 eqiv.)	0	0	0
RESULTS			
4. Reduction in GHG emissions due to improvement of site			
Reduction in GHG emissions due to improvement (t CO2 equiv.)	0	0	0